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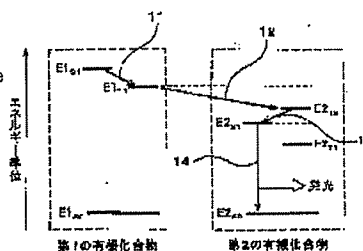
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(54) ORGANIC ELECTRO LUMINESCENCE ELEMENT AND LUMINESCENT MATERIAL

(57)Abstract:

PROBLEM TO BE SOLVED: To provide an organic EL(electro luminescent element) having high luminous efficiency and high brightness and long durability, in which an internal quantum efficiency exceeds 25% that is hitherto said to be the limit value of the efficiency as a luminescent material used for the organic EL element, and which can further respond to all the luminescent colors needed for display.

SOLUTION: The luminescent material of high luminous efficiency and the organic EL element are obtained by using two sorts of organic compounds which have a relation of an energy level of an excitation state so that an energy transfer is performed from an excitation triplet state of one of these compounds to the excitation triplet state of the other compound as two sorts of organic compounds contributing to luminescence.



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CLAIMS

[Claim(s)]

[Claim 1] Two or more sorts of organic compounds are contained in a luminous layer. About two sorts of organic compounds of them Energy-level E1T1 of the minimum excitation triplet state of the 1st organic compound is higher than energy-level E2S1 of the minimum excitation singlet state of the 2nd organic compound. And the organic electroluminescent element characterized by for at least one energy level of the excitation triplet state of said 2nd organic compound existing between E1T1 and E2S1, and emitting light from the 2nd organic compound.

[Claim 2] Three or more sorts of organic compounds are contained in a luminous layer. About three sorts of organic compounds of them Energy-level E1T1 of the minimum excitation triplet state of the 1st organic compound is higher than energy-level E2S1 of the minimum excitation singlet state of the 2nd organic compound. And at least one energy level of the excitation triplet state of said 2nd organic compound exists between E1T1 and E2S1. Furthermore, between energy-level E1S1 of the minimum excitation singlet state of said 1st organic compound, energy-level E1T1 of the minimum excitation triplet state and energy-level E3S1 of the minimum excitation singlet state of the 3rd organic compound, and energy-level E3T1 of the minimum excitation triplet state The organic electroluminescent element characterized by having the relation of $E3S1 > E1S1E3T1 > E1T1$, and emitting light from the 2nd organic compound.

[Claim 3] An anode plate, a luminous layer according to claim 1 or 2, the organic electroluminescent element constituted in order of cathode.

[Claim 4] An anode plate, a hole transportation layer, a luminous layer according to claim 1 or 2, an electronic transportation layer, the organic electroluminescent element constituted in order of cathode.

[Claim 5] The organic electroluminescent element according to claim 1 to 4 whose luminescence of said 2nd organic compound is fluorescence.

[Claim 6] The organic electroluminescent element according to claim 1 to 5 said whose 1st organic compound is a transition metal complex.

[Claim 7] The organic electroluminescent element according to claim 1 to 5 said whose 1st organic compound is a rare earth metal complex.

[Claim 8] Luminescent material characterized by containing two or more sorts of organic compounds in a luminous layer, and energy-level E1T1 of the minimum excitation triplet state of the 1st organic compound being higher than energy-level E2S1 of the minimum excitation singlet state of the 2nd organic compound, and for at least one energy level of the excitation triplet state of said 2nd organic compound existing between E1T1 and E2S1 about two sorts of organic compounds of them, and emitting light from the 2nd organic compound.

[Claim 9] Three or more sorts of organic compounds are contained in a luminous layer. About three sorts of organic compounds of them Energy-level E1T1 of the minimum excitation triplet state of the 1st organic compound is higher than energy-level E2S1 of the minimum excitation singlet state of the 2nd organic compound. And at least one energy level of the excitation triplet state of said 2nd organic compound exists between E1T1 and E2S1. Furthermore, between energy-level E1S1 of the minimum excitation singlet state of said 1st organic compound, energy-level E1T1 of the minimum excitation triplet state and energy-level E3S1 of the minimum excitation singlet state of the 3rd organic compound, and energy-level E3T1 of the minimum excitation triplet state Luminescent material characterized by having the relation of $E3S1 > E1S1E3T1 > E1T1$, and emitting light from the 2nd organic compound.

[Claim 10] Luminescent material according to claim 8 to 9 whose luminescence of said 2nd organic compound is fluorescence.

[Claim 11] Luminescent material according to claim 8 to 10 characterized by said 1st organic compound being a transition metal complex.

[Claim 12] Luminescent material according to claim 8 to 10 characterized by said 1st organic compound being a rare earth metal complex.

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the organic electroluminescent element for back lights (it is only hereafter called an "organic EL device") used for a flat-surface display panel or this.

[0002]

[Description of the Prior Art] Luminescence of high brightness was shown by C.W.Tang and others of KODAKKU in 1987, ingredient development and amelioration of component structure have progressed quickly, and, as for an organic EL device, utilization has recently begun from a car audio, the display for cellular phones, etc. since then (Appl.Phys.Let., 51 volumes, 913 pages, 1987). In order to expand the application of this organic electroluminescence further, ingredient development for the improvement in luminous efficiency and the improvement in endurance, development of a full color display, etc. are performed actively now. When considering the expansion to a medium size panel, a large-sized panel, or a lighting application especially, the further raise in brightness by improvement in luminous efficiency is required. However, luminescence from an excitation singlet state, i.e., fluorescence, is used [25% of] by current luminescent material, and according to a monthly display, the October, 1988 issue separate volume "an organic electroluminescence display", and 58 pages, since the generation ratio of an excitation singlet state and an excitation triplet state in electric excitation is 1:3, as for the internal quantum efficiency in firefly luminescence, it has been made into an upper limit.

[0003] On the other hand, M.A.Baldo and others acquired 7.5% (when external ejection effectiveness is assumed to be 20%, internal quantum efficiency is 37.5%) of external quantum efficiency by using the iridium complex which carries out phosphorescence luminescence from an excitation triplet state, and it was shown that it is possible to exceed the value of 25% conventionally made into a upper limit (Appl.Phys.Lett., 75 volumes, 4 pages, 1999). However, in order for the ingredient which emits phosphorescence to stability in ordinary temperature like the iridium complex used here to excite electrically very rarely, it needed to be doped and used for the specific host compound, and it had the fault that the material selection for realizing luminescence wavelength required as a display was very difficult.

[0004] On the other hand, similarly, M.A.Baldo and others used the iridium complex as a sensitizer, energy was moved to the excitation singlet state of a fluorochrome from this excitation triplet state, and by making fluorescence emit light from the excitation singlet state of a fluorochrome finally showed that comparatively good luminous efficiency was acquired (Nature, 403 volumes, 750 pages, 2000). This approach has the advantage that the thing suitable for the purpose can be selected and used from many fluorochromes as a luminescent material. However, in this approach, since the process of spin prohibition called the energy transfer from the excitation triplet state of a sensitizer to the excitation singlet state of a fluorochrome was included, there was a big fault that luminescence quantum efficiency was low, theoretically.

[0005]

[Problem(s) to be Solved by the Invention] As mentioned above, 25% which is the threshold value of the internal quantum efficiency said from the former as a luminescent material used for an organic EL device is exceeded, and what can respond to all the luminescent color further needed as a display does not yet exist. Moreover, a high luminous efficiency ingredient has little energy loss, and since generation of heat of a component is suppressed, it is demanded also from a viewpoint of the improvement in endurance of a component. This invention solves the trouble of such a

conventional technique, and makes it a technical problem to offer the organic EL device which is durable by high brightness, and the luminescent material used for this.

[0006]

[Means for Solving the Problem] this invention persons came to complete a header and this invention for efficient luminescence being obtained by using two sorts of organic compounds which have the relation of the energy level of an excitation state to which energy transfer is carried out from one excitation triplet state of these compounds to the excitation triplet state of another side as two sorts of organic compounds contributed to luminescence, as a result of examining many things that the above-mentioned technical problem should be solved.

[0007] That is, this invention relates to the luminescent material used for the following organic electroluminescent elements and this.

[0008] Two or more sorts of organic compounds are contained in a luminous layer. [1] About two sorts of organic compounds of them Energy-level E1T1 of the minimum excitation triplet state of the 1st organic compound is higher than energy-level E2S1 of the minimum excitation singlet state of the 2nd organic compound. And the organic electroluminescent element characterized by for at least one energy level of the excitation triplet state of said 2nd organic compound existing between E1T1 and E2S1, and emitting light from the 2nd organic compound.

[0009] Three or more sorts of organic compounds are contained in a luminous layer. [2] About three sorts of organic compounds of them Energy-level E1T1 of the minimum excitation triplet state of the 1st organic compound is higher than energy-level E2S1 of the minimum excitation singlet state of the 2nd organic compound. And at least one energy level of the excitation triplet state of said 2nd organic compound exists between E1T1 and E2S1. Furthermore, between energy-level E1S1 of the minimum excitation singlet state of said 1st organic compound, energy-level E1T1 of the minimum excitation triplet state and energy-level E3S1 of the minimum excitation singlet state of the 3rd organic compound, and energy-level E3T1 of the minimum excitation triplet state The organic electroluminescent element characterized by having the relation of $E3S1 > E1S1E3T1 > E1T1$, and emitting light from the 2nd organic compound.

[0010] [3] An anode plate, a luminous layer according to claim 1 or 2, the organic electroluminescent element constituted in order of cathode.

[0011] [4] An anode plate, a hole transportation layer, a luminous layer according to claim 1 or 2, an electronic transportation layer, the organic electroluminescent element constituted in order of cathode.

[0012] [5] The organic electroluminescent element according to claim 1 to 4 whose luminescence of said 2nd organic compound is fluorescence.

[0013] [6] The organic electroluminescent element according to claim 1 to 5 said whose 1st organic compound is a transition metal complex.

[0014] [7] The organic electroluminescent element according to claim 1 to 5 said whose 1st organic compound is a rare earth metal complex.

[0015] Two or more sorts of organic compounds are contained in a luminous layer. [8] About two sorts of organic compounds of them Energy-level E1T1 of the minimum excitation triplet state of the 1st organic compound is higher than energy-level E2S1 of the minimum excitation singlet state of the 2nd organic compound. And luminescent material characterized by for at least one energy level of the excitation triplet state of said 2nd organic compound existing between E1T1 and E2S1, and emitting light from the 2nd organic compound.

[0016] Three or more sorts of organic compounds are contained in a luminous layer. [9] About three sorts of organic compounds of them Energy-level E1T1 of the minimum excitation triplet state of the 1st organic compound is higher than energy-level E2S1 of the minimum excitation singlet state of the 2nd organic compound. And at least one energy level of the excitation triplet state of said 2nd organic compound exists between E1T1 and E2S1. Furthermore, between energy-level E1S1 of the minimum excitation singlet state of said 1st organic compound, energy-level E1T1 of the minimum excitation triplet state and energy-level E3S1 of the minimum excitation singlet state of the 3rd organic compound, and energy-level E3T1 of the minimum excitation triplet state Luminescent material characterized by having the relation of $E3S1 > E1S1E3T1 > E1T1$, and emitting light from the 2nd organic compound.

[0017] [10] Luminescent material according to claim 8 to 9 whose luminescence of said 2nd organic compound is fluorescence.

[0018] [11] Luminescent material according to claim 8 to 10 characterized by said 1st organic compound being a transition metal complex.

[0019] [12] Luminescent material according to claim 8 to 10 characterized by said 1st organic compound being a rare earth metal complex.

[0020]

[Embodiment of the Invention] Hereafter, the gestalt of operation of this invention is concretely explained with reference to a drawing.

[0021] Drawing 1 is the sectional view showing an example of the organic EL device configuration of this invention, and prepares a hole transportation layer, a luminous layer, and an electronic transportation layer one by one between the anode plates and cathode which were prepared on the transparency substrate. The organic EL device configuration of this invention is not limited only to the example of drawing 1. Between an anode plate and cathode moreover, one by one 1) A hole transportation layer / luminous layer, 2 luminous layers / electronic transportation layer, and the thing that prepared whether it was ***** may be used. Furthermore, it is also good to prepare further the layer of the layer containing the layer containing the layer containing 3 hole transportation ingredient, luminescent material, and an electronic transportation ingredient, 4 hole transportation ingredient, and luminescent material, 5 luminescent material, and an electronic transportation ingredient, the independent layer of 6 luminescent material, and ***** . Moreover, although the number of the luminous layers shown in drawing 1 is one, the laminating of the two or more layers may be carried out.

[0022] The relation of the energy level of the organic compound which constitutes the luminous layer of the organic EL device applied to the 1st operation gestalt of this invention at drawing 2 is shown. The luminous layer of the luminous layer of the organic EL device shown in drawing 2 At least two or more sorts of organic compounds, Namely, the 1st organic compound which does not emit light, and the 2nd organic compound which emits light are contained. Energy-level E1T1 of the minimum excitation triplet state of the 1st organic compound is higher than energy-level E2S1 of the minimum excitation singlet state of the 2nd organic compound. And it has the relation that at least one energy level of the excitation triplet state of the 2nd organic compound exists between E1T1 and E2S1. Although here has shown the case where energy-level E2T2 of the 2nd excitation triplet state exist in drawing 2 from the lower one in the 2nd organic compound between E1T1 and E2S1, between E1T1 and E2S1, one or more energy levels of the 3rd excitation triplet state beyond it may exist from the lower one in the 2nd organic compound.

[0023] As the 1st organic compound, that to which the intersystem crossing from an excitation singlet state to an excitation triplet state tends to happen is desirable, and the ingredient which is easy to emit light in phosphorescence speaking of luminescence is desirable. As a value of the quantum efficiency of the above-mentioned intersystem crossing, 0.1 or more are 0.3 or more desirable still more preferably, and it is 0.5 or more much more preferably.

[0024] Although a transition metal complex and a rare earth metal complex can be illustrated as a concrete compound, it is not limited to these at all.

[0025] As transition metals used for the above-mentioned transition metal complex, although Cr, Mn, Fe, Co, nickel, Ru, Rh, Pd, Os, Ir, Pt, etc. can be illustrated, it is not limited to these at all. In addition, as transition metals, it takes into consideration to the ionic state of an element here, and the 2nd sere includes even Ag (II) and, as for the 3rd sere, the 1st sere includes even Cu (II) even for Au (II).

[0026] As a rare earth metal used for the above-mentioned rare earth metal complex, although La, Nd, Sm, Eu, Gd, Tb, Dy, Er, Lu, etc. can be illustrated, it is not limited to these at all.

[0027] moreover -- as the ligand used for these transition metals or a rare earth metal complex -- acetylacetonato, and 2 and 2 - bipyridine, and '4, 4' -- the - dimethyl - 2 and 2' -- although - bipyridine, 1, 10-phenanthroline, 2-phenyl pyridine, a porphyrin, a phthalocyanine, etc. can be illustrated, it is not limited to these at all. As for these ligands, coordination of one kind or two or more kinds is carried out about one complex.

[0028] Furthermore, the double complex of a dinuclear complex or two or more kinds of complexes can also be used as the above-mentioned complex compound.

[0029] The compound which emits fluorescence including the various coloring matter known from the former as the 2nd organic compound can be used. That to which the reverse intersystem crossing from an excitation triplet state to an excitation singlet state tends [especially] to happen is desirable. As a value of the quantum efficiency of the above-mentioned reverse intersystem crossing, 0.1 or more are 0.3 or more desirable still more preferably, and it is 0.5 or more much more preferably. 9 and 10-dibromo anthracene (H. Fukumura et al., J.Photochem.Photobiol., A:Chemistry, 42 volumes, 283 pages, 1988) whose quantum efficiency of reverse intersystem crossing is 0.19 as such a thing,

Although the quantum efficiency of reverse intersystem crossing can illustrate about 0.7 a rhodamine 101, similar cyanine dye (R. W.Redmond et al., J.Phys.Chem.A, 101 volumes, 2773 pages, 1997), etc. It is not limited to these at all.

[0030] The luminous layer of the organic EL device of the 1st operation gestalt contains the 1st above-mentioned organic compound and 2nd above-mentioned organic compound. In this case, the 1st organic compound and 2nd organic compound may be contained in one layer, each is contained in the separate layer, the laminating of two-layer [these] or the layer beyond it is carried out, and it may form one luminous layer. Moreover, compounds other than the 1st organic compound and the 2nd organic compound may be contained in above-mentioned each class. The thickness of a luminous layer has 10nm - desirable 1 micrometer, and its 10-100nm is still more desirable.

[0031] In the 1st operation gestalt, the mechanism of luminescence in the case of having the relation an energy level is indicated to be to drawing 2 is as follows. That is, finally the minimum excitation singlet state (energy-level E1S1) and the minimum excitation triplet state (energy-level E1T1) generate at 25% : 75% of a rate to the 1st organic compound by electric excitation. Here, it changes from the minimum excitation singlet state to the minimum excitation triplet state by intersystem crossing 11, and the ratio of the minimum excitation triplet state increases to 75% or more.

[0032] Next, energy transfer 12 happens from the lower one of the minimum excitation triplet state (energy-level E1T1) of the 1st organic compound to the 2nd organic compound to the 2nd excitation triplet state (energy-level E2T2) or the excitation triplet state (not shown) of the lower one to the 3rd henceforth. Here, although the energy transfer from the minimum excitation singlet state (energy-level E1S1) to the excitation singlet state of the 2nd organic compound of the 1st organic compound (energy-level E2S1) may also happen, the contribution is small if it sees from the whole, since the ratio of the minimum excitation singlet state (energy-level E1S1) of the 1st organic compound is lower than 25% by intersystem crossing.

[0033] Next, fluorescence is emitted in the process 14 which the 2nd excitation triplet state (energy-level E2T2) or the excitation triplet state (not shown) of the lower one to the 3rd henceforth changes from the lower one of the 2nd organic compound by the reverse intersystem crossing 13 to the minimum excitation singlet state (energy-level E2S1) of the 2nd organic compound, and changes from here to a ground state (energy-level E2S0).

[0034] The relation of the energy level of the organic compound which constitutes the luminous layer of the organic EL device applied to the 2nd operation gestalt of this invention at drawing 3 is shown. The relation of the energy level shown in drawing 3 adds relation with the energy level of the 3rd organic compound further contained in a luminous layer to the relation of the energy level of the 1st organic compound shown in drawing 2 , and the 2nd organic compound. That is, energy-level E3S1 of the minimum excitation singlet state of the 3rd organic compound has the relation that energy-level E3T1 of the minimum excitation triplet state of the 3rd organic compound is higher than energy-level E1T1 of the minimum excitation triplet state of the 1st organic compound, more highly than energy-level E1S1 of the minimum excitation singlet state of the 1st organic compound.

[0035] The 3rd organic compound will not be limited especially if the relation of the above-mentioned energy level is filled.

[0036] The luminous layer of the organic EL device of the 2nd operation gestalt contains the 1st organic compound, 2nd above-mentioned organic compound, and 3rd above-mentioned organic compound. The 1st organic compound, 2nd organic compound, and 3rd organic compound may be contained in one layer, and one or 2 of these three compounds are contained in one layer, the laminating of two-layer [these] or the layer beyond it is carried out, and it may form a luminous layer. Compounds other than the 1st organic compound, the 2nd organic compound, and the 3rd organic compound may be contained in above-mentioned each class. The thickness of a luminous layer has 10nm - desirable 1 micrometer, and its 10-100nm is still more desirable.

[0037] In the 2nd operation gestalt, the mechanism of luminescence in the case of having the relation an energy level is indicated to be to drawing 3 is as follows. That is, finally the minimum excitation singlet state (energy-level E3S1) and the minimum excitation triplet state (energy-level E3T1) generate at 25% : 75% of a rate to the 3rd organic compound by electric excitation.

[0038] Next, energy transfer 15 arises from the minimum excitation singlet state (energy-level E3S1) of the 3rd organic compound to the minimum excitation singlet state (energy-level E1S1) of the 1st organic compound. Or energy transfer happens from the lower one of the minimum excitation singlet state (energy-level E3S1) of the 3rd organic compound to the 1st organic compound to the excitation singlet state (not shown) of the 2nd henceforth, and it changes to the

minimum excitation singlet state (energy-level E1S1) by internal conversion further. On the other hand, energy transfer 16 arises from the minimum excitation triplet state (energy-level E3T1) of the 3rd organic compound to the minimum excitation triplet state (energy-level E1T1) of the 1st organic compound. Or energy transfer happens from the lower one of the minimum excitation triplet state (energy-level E3T1) of the 3rd organic compound to the 1st organic compound to the excitation triplet state (not shown) of the 2nd henceforth, and it changes to the minimum excitation triplet state (energy-level E1T1) by internal conversion further.

[0039] It changes to the minimum excitation triplet state (energy-level E1T1) by intersystem crossing 11 according to the same mechanism as the 1st above-mentioned operation gestalt after that from the minimum excitation singlet state (energy-level E1S1) of the 1st organic compound. The lower one of here to the 2nd organic compound to the 2nd excitation triplet state (energy-level E2T2), Or energy transfer 12 happens from the lower one to the excitation triplet state (not shown) of the 3rd henceforth, and fluorescence is further emitted through the reverse intersystem crossing 13 to the minimum excitation singlet state in the process 14 which returns to a ground state.

[0040] As a hole transportation ingredient which forms the hole transportation layer of the organic EL device concerning this invention, TPD (N, N'-diphenyl-N, N' - (3-methylphenyl) -1, the 1'-biphenyl -4, 4'-diamine), Alpha-NPD (N, N' - diphenyl-N, N' - (1-naphthyl) -1, the 1'-biphenyl -4, 4'-diamine), Although known hole transportation ingredients, such as triphenylamine derivatives, such as m-MTDATA (4, 4', 4''-tris-[N-(3-methylphenyl)-N-phenylamino] triphenylamine), a polyvinyl carbazole, and polyethylene dioxythiophene, can be used It is not limited to especially these. Although these hole transportation ingredients are used even when they are independent, with a different hole transportation ingredient, a laminating may be mixed or carried out and they may be used. Although limitation is impossible generally since the thickness of a hole transportation layer is based also on the conductivity of a hole transportation layer, 10nm - 10 micrometers are desirable, and 10nm - 1 micrometer is still more desirable.

[0041] Although known electronic transportation ingredients, such as quinolinol derivative metal complexes, such as Alq3 (tris (eight quinolinol) aluminum), an OKISA diazole derivative, and a triazole derivative, can be used as an electronic transportation ingredient which forms the electronic transportation layer of the organic EL device concerning this invention, it is not limited to especially these. Although these electronic transportation ingredients are used even when they are independent, with a different electronic transportation ingredient, a laminating may be mixed or carried out and they may be used. Although limitation is impossible generally since the thickness of an electronic transportation layer is based also on the conductivity of an electronic transportation layer, 10nm - 10 micrometers are desirable, and 10nm - 1 micrometer is still more desirable.

[0042] The organic compound, hole transportation ingredient, and electronic transportation ingredient which are used for the above-mentioned luminous layer form each class independently, respectively, and also can also form each class by using polymeric materials as a binder. As polymeric materials used for this, although polymethylmethacrylate, a polycarbonate, polyester, polysulfone, polyphenylene oxide, etc. can be illustrated, it is not limited to especially these.

[0043] The membrane formation approach of the organic compound used for the above-mentioned luminous layer, a hole transportation ingredient, and an electronic transportation ingredient can use resistance heating vacuum deposition, electron beam vacuum deposition, the sputtering method, a coating method, etc., and is not limited to especially these. In the case of a low molecular weight compound, resistance heating vacuum evaporation and electron beam evaporation are mainly used, and when it is polymeric materials, a coating method is mainly used.

[0044] Although known transparence electrical conducting materials, such as conductive polymers, such as ITO (indium tin oxide), tin oxide, a zinc oxide, the poly thiophene, polypyrrole, and the poly aniline, can be used as an anode material of the organic EL device concerning this invention, it is not limited to especially these. As for the surface electrical resistance of the electrode by this transparence electrical conducting material, it is desirable that they are 1-50ohm/** (an ohm/square). As the membrane formation approach of these anode materials, although electron beam vacuum deposition, the sputtering method, a chemical reaction method, a coating method, etc. can be used, it is not limited to especially these. The thickness of an anode plate has desirable 50-300nm.

[0045] Moreover, between the organic layers by which adjoin an anode plate, a hole transportation layer, or an anode plate, and a laminating is carried out, the buffer layer may be inserted in order to ease the impregnation obstruction over hole impregnation. Although known ingredients, such as a copper phthalocyanine, are used for this, it is not limited to especially this.

[0046] Although known cathode materials, such as an alloy of aluminum, such as alkali metal, such as aluminum, a

MgAg alloy, and calcium, and AlCa, and alkali metal, can be used as a cathode material of the organic EL device concerning this invention, it is not limited to especially these. As the membrane formation approach of these cathode materials, although resistance heating vacuum deposition, electron beam vacuum deposition, the sputtering method, the ion plating method, etc. can be used, it is not limited to especially these. The thickness of cathode has 10nm - desirable 1 micrometer, and its 50-500nm is still more desirable.

[0047] Moreover, between the organic layers by which adjoin cathode, and an electronic transportation layer or cathode, and a laminating is carried out, the insulating layer with a thickness of 0.1-10nm may be inserted in order to raise electron injection effectiveness. Although known ingredients, such as lithium fluoride, magnesium fluoride, a magnesium oxide, and an alumina, can be used as this insulating layer, it is not limited to especially these.

[0048] Moreover, the cathode side of a luminous layer is adjoined and the Hall Brock layer may be prepared the suppressing that a hole passes a luminous layer and making it recombine with an electron efficiently within a luminous layer purpose. Although known ingredients, such as a triazole derivative and an OKISA diazole derivative, are used for this, it is not limited to especially this.

[0049] Although a transparent insulating substrate can be used to the luminescence wavelength of luminescent material as a substrate of the organic EL device concerning this invention and known ingredients, such as transparent plastics including others, PET (polyethylene terephthalate), and a polycarbonate, can be used, it is not limited to especially these. [glass]

[0050] The organic EL device of this invention can constitute the pixel by the matrix method or the segment method from a known approach. Moreover, it is also possible to use as a back light, without forming a pixel.

[0051]

[Example] Hereafter, although an example and the example of a comparison explain this invention in more detail, this invention is not limited only to the following examples.

[0052] The parameter and measuring method in this example and the example of a comparison are explained. The thickness of a <thickness> organic layer is a product made from SLOAN. DEKTAK It measured using 3030 (sensing-pin type thickness measurement equipment).

[0053] The emission spectrum in the solution of <emission spectrum of solution> luminescent material is the Jasco Corp. make. It measured using spectrophotofluorometer FP-6500.

[0054] Measurement of the fluorescence intensity emitted by <fluorescence intensity> laser radiation was performed by [as being the following]. Incidence of the outgoing radiation light from a sample was carried out to the spectroscopy (the product made from McPherson, 270 molds), the spectrum of the fluorescence was carried out, the photo-multiplier (the Hamamatsu Photonics make, R636) detected this, this output was observed with the digital oscilloscope (the product made from Lecroy, 9450 molds), and the personal computer performed data analysis.

[0055] The compound (it considers as compound A hereafter) and quencher which are set as the object of <energy level of excitation triplet state> measurement are melted to a solvent, and the 1st pulse laser with pulse width shorter enough than the life of the excitation triplet state of compound A is irradiated on the wavelength on which compound A has absorption. this should pass the minimum excitation singlet state (energy level EaS1) in compound A -- the minimum excitation triplet state (energy level EaT1) arises, and the minimum excitation triplet state continues also after a pulse laser exposure.

[0056] Next, while the minimum excitation triplet state is continuing to compound A, the compound A in the minimum excitation triplet state (after quenching fluorescence) irradiates the 2nd pulse laser of wavelength which has absorption. Thereby, compound A is excited by the triplet state (EaTn) with a still higher energy level. Here, when compound A assumes reverse intersystem crossing that there are not a lifting and a quencher, compound A will change from this high energy level (EaTn) to the minimum excitation singlet state (EaS1) by reverse intersystem crossing, and will emit fluorescence.

[0057] When a quencher exists and what has it exists in the excitation triplet state of compound A ($EaS1 < EaTn < EqT1$), this excitation triplet state does not receive deactivation by the quencher, but compound A changes from this high excitation triplet state (EaTn) to the minimum excitation singlet state (EaS1) by reverse intersystem crossing, and emits fluorescence from here. [higher / than the energy level EaS1 of the minimum excitation singlet state of compound A / that energy level and lower than the energy level EqT1 of the minimum excitation triplet state of a quencher]

[0058] On the other hand, the energy level is higher than the energy level EaS1 of the minimum excitation singlet state

of compound A in the excitation triplet state of compound A. And although compound A is excited by the excitation triplet state ($E_{aTn} > E_{qT1}$) higher than the energy level E_{qT1} of the minimum excitation triplet state of a quencher by the 2nd pulse laser exposure when a thing lower than the energy level E_{qT1} of the minimum excitation triplet state of a quencher does not exist in order that this excitation triplet state may receive deactivation by the quencher, compound A should pass reverse intersystem crossing from this high excitation triplet state -- or [that the fluorescence which emits light from the minimum excitation singlet state can be weakened] -- or it quenches.

[0059] Therefore, when the fluorescence of level [equivalent also when there is a quencher compared with the fluorescence intensity from the compound A observed when the 2nd pulse laser is irradiated (when you have no quencher)] on the strength is observed, it turns out that the excitation triplet state ($E_{aS1} < E_{aTn} < E_{qT1}$) which has an energy level exists between the energy level E_{aS1} of the minimum excitation singlet state of compound A, and the energy level E_{qT1} of the minimum excitation triplet state of a quencher at compound A. or [that fluorescence in case there is a quencher compared with the fluorescence intensity from the compound A (with no quencher) observed on the other hand when the 2nd pulse laser is irradiated is weak] -- or when [to cut] not observed, it turns out that the excitation triplet state which has an energy level between the energy level E_{aS1} of the minimum excitation singlet state of compound A and the energy level E_{qT1} of the minimum excitation triplet state of a quencher does not exist at compound A.

[0060] The range of the energy level ($E_{aTn} \geq 2$) of a high excitation triplet state of an energy level becomes settled from the minimum excitation triplet state of compound A by measurement using the above quenchers. For raising precision more, it is desirable to repeat the same measurement using the quencher which has the energy level of a different minimum excitation triplet state.

[0061] As a <luminescence brightness> power source, it is ADVANTEST CORP. Make. An electrical potential difference is impressed to the organic light emitting device obtained in the example and the example of a comparison using programmable direct current voltage / current source TR6143, and it is TOPCON CORP. Make about luminescence brightness. Luminance meter It measured using BM-8.

[0062] (Example 1)

(1) The measurement fac-tris (2-phenyl pyridine) iridium of energy-level E_{1T1} of the minimum excitation triplet state of fac-tris (2-phenyl pyridine) iridium is KDedeian et al., Inorganic Chemistry, Vol.30, No.8, and p.1685 (1991). It compounded based on the indicated synthetic approach.

[0063] 10-5M of fac-tris (2-phenyl pyridine) iridium The chloroform solution was produced and the emission spectrum was measured with the spectrophotofluorometer. Consequently, the peak wavelength of a phosphorescence spectrum is 510nm, and energy-level E_{1T1} of the minimum excitation triplet state was calculated with $19,600\text{cm}^{-1}$ ($1 / 510 \times 10^{-7}$) from this.

[0064] (2) The measurement rhodamine 101 of energy-level E_{2S1} of the minimum excitation singlet state of a rhodamine 101 (Rhodamine101) did not refine what was purchased from Fluka, but used it as it was. 10-5M of a rhodamine 101 Methanol solution was produced and the emission spectrum was measured with the spectrophotofluorometer. Consequently, excitation peak wavelength was 570nm and fluorescence peak wavelength was 590nm. From this, energy-level E_{2S1} of the minimum excitation singlet state was calculated by taking the average of the energy both wavelength with $17,100\text{cm}^{-1}$ ($1 / 570 \times 10^{-7} + 1 / 590 \times 10^{-7}$) (/2).

[0065] (3) Although the minimum excitation triplet state of a rhodamine 101 was made in the wavelength which has absorption, the exposure by the 2nd pulse laser of measurement of the T-T absorption spectrum of a rhodamine 101 performed measurement of the absorption spectrum of the minimum excitation triplet state, i.e., a T-T absorption spectrum, with the transient absorption measuring method (for example, a 4th edition experimental science lecture, the 7th volume, spectrum II 275 pages, 1992, and Maruzen reference) usually performed, in order to decide this.

[0066] 10-5M of a rhodamine 101 When produced methanol solution, and irradiated the second harmonic (wavelength: 532nm, output: 15mJ / pulse, pulse width: 5ns) of Nd:YAG laser (the product made from Spectra Physics, GCR14), this was made to generate the minimum excitation triplet state and the T-T absorption spectrum of this condition was measured, the broadcloth peak was shown near 600nm. From this, the wavelength of the 2nd pulse laser was determined as 690nm.

[0067] (4) 10-5M of the measurement rhodamine 101 of energy-level $E_{2Tn} \geq 2$ of the excitation triplet state 2nd after a rhodamine 101 Methanol solution was produced. Fluorescence was observed, when the second harmonic (wavelength:

532nm, output:15mJ / pulse, pulse width:5ns) of Nd:YAG laser (the product made from Spectra Physics, GCR14) was irradiated and excimer laser excitation dye laser (the product made from Lumonics, HyperDYE300, wavelength:690nm, output:5mJ / pulse, pulse width: 20ns) was irradiated after 15microsec at this. Moreover, fluorescence was not observed when the 1st pulse laser was not irradiated. This showed that fluorescence emitted light by the reverse intersystem crossing from the high excitation triplet state of the energy level of a rhodamine 101 to the minimum excitation singlet state.

[0068] Next, beta-ionone as a rhodamine 101 and a quencher was dissolved in the methanol. The rhodamine 101 adjusted concentration so that 10-5M and beta-ionone might be set to 10-2M. In addition, the energy level EqT1 of the minimum excitation triplet state of beta-ionone is "Handbook. of Photochemistry, Second Edition (work besides Steven L. Murov, Marcel DekkerInc., 1993) shows that it is 19,200cm⁻¹.

[0069] this solution -- Nd:YAG laser (the product made from Spectra Physics --) the second harmonic (wavelength: -- 532nm, and output:15mJ / pulse --) of GCR14 pulse width: -- 5ns -- irradiating -- after 15microsec -- excimer laser excitation dye laser (the product made from Lumonics --) HyperDYE300, wavelength:690nm, output:5mJ / pulse, pulse width: When 20ns was irradiated, the fluorescence of the reinforcement of the case where there is no beta-ionone, and this level was observed. Moreover, even if it made the concentration of beta-ionone increase even to 1M, quenching did not happen but the fluorescence of the reinforcement of the case where there is no beta-ionone similarly, and this level was observed.

[0070] Since firefly luminescence of the rhodamine 101 was carried out by reverse intersystem crossing, the above thing showed having an excitation triplet state in an energy level higher than energy-level E2S1 of the minimum excitation singlet state, and 17,100cm⁻¹. Moreover, since fluorescence did not quench even when beta-ionone existed, it turned out that it has an excitation triplet state (E2Tn) in an energy level lower than energy-level 19,200cm⁻¹ of the minimum excitation triplet state of beta-ionone. Therefore, it turned out that a rhodamine 101 has an excitation triplet state in the energy level between 17,100cm⁻¹ and 19,200cm⁻¹.

[0071] (5) The organic EL device was produced using the substrate with ITO (Nippo Electric, Nippo Electric Co., LTD.) with which two ITO electrodes with a width of face [used as an anode plate] of 4mm were formed in one field of the glass substrate of 25mm angle of production of an EL element in the shape of a stripe.

[0072] First, on ITO (anode plate) of a substrate with ITO, after applying Pori (3, 4-ethylene dioxythiophene) and polystyrene sulfonate (the Bayer make, trade name "BAITORONP") with a spin coat method on rotational frequency 3500rpm and the conditions for spreading time amount 40 seconds, the bottom of reduced pressure was performed by the vacuum desiccator, desiccation was performed at 60 degrees C for 2 hours, and the anode plate buffer layer was formed. The thickness of the obtained anode plate buffer layer was about 50nm.

[0073] Next, the spreading solution for forming the layer containing a hole transportation ingredient, luminescent material, and an electronic transportation ingredient was prepared. After mixing these with the compounding ratio shown in Table 1 using the luminescent material shown in Table 1, a hole transportation ingredient, an electronic transportation ingredient, and a solvent, the obtained solution was filtered with the filter of 0.2 micrometers of apertures, and it considered as the spreading solution. Each ingredient was used as it was, without refining the artificer synthetic compounds and the purchase article which are shown below.

Luminescent material: fac-tris (2-phenyl pyridine) iridium (the above-mentioned synthetic compounds)

: Rhodamine 101 (product made from Fulka)

Hole transportation ingredient: Pori (N-vinylcarbazole) (Tokyo formation make)

electronic transportation ingredient: -- 2-(4-biphenyl)-5-(4-tert-buthylphenyl)- 1, 3, and 4-OKISA diazole (PBD) (Tokyo formation make)

Solvent : chloroform (the product made from the Wako Pure Chem industry, best)

[0074] Next, the layer containing a hole transportation ingredient, luminescent material, and an electronic transportation ingredient was formed on the anode plate buffer layer by applying the prepared spreading solution on rotational frequency 3000rpm and the conditions for spreading time amount 30 seconds, and drying it for 30 minutes at a room temperature (25 degrees C) with a spin coat method. The thickness of the layer containing the obtained hole transportation ingredient, luminescent material, and an electronic transportation ingredient was about 120nm.

[0075] Next, the substrate in which the layer containing a hole transportation ingredient, luminescent material, and an electronic transportation ingredient was formed was laid in vacuum evaporatio equipment, vapor codeposition of

silver and the magnesium was carried out at a rate of the weight ratio 1:10, and two cathode with a width of face of 3mm arranged in the shape of a stripe was formed. In addition, cathode was formed in the direction which intersects perpendicularly to the extension direction of an anode plate. The thickness of the obtained cathode was about 50nm. [0076] Finally, lead wire (wiring) was attached into argon atmosphere in an anode plate and cathode, and four 4mm long and 3mm wide organic EL devices were produced.

[0077] (6) When the electrical potential difference was impressed to the organic EL device of the evaluation above of a luminescence property and luminescence brightness was measured, the luminescence brightness when impressing an electrical potential difference 20V was 22 cd/m².

[0078] (Example 1 of a comparison) The organic EL device was obtained like the example except having considered as the combination which shows the spreading solution at the time of forming the layer containing a hole transportation ingredient, luminescent material, and an electronic transportation ingredient in Table 1. In addition, in the example of a comparison, as shown in Table 1, fac-tris (2-phenyl pyridine) iridium was not used.

[0079] When the electrical potential difference was impressed to the above-mentioned organic EL device and luminescence brightness was measured, the luminescence brightness when impressing an electrical potential difference 20V was 3 cd/m².

[0080]

[Table 1]

		配合量 (mg)	
		実施例 1	比較例 1
発光材料	fac-トリス(2-フェニルピリジン)イリジウム	0.02	-
	ローダミン101	0.10	0.10
ホール輸送材料	ポリ(N-ビニルカルbazol)	15.88	15.88
電子輸送材料	PBD	4.00	4.00
溶剤	クロロホルム	1980	1980
発光輝度 (cd/m ²)		22	3

[0081] (Example 2) The Nile red (Nile Red, product made from Across) was used instead of the rhodamine 101, and the organic EL device was obtained like the example 1 except having considered as the combination which shows the spreading solution in the case of component production in Table 2. In addition, the excitation peak wavelength of the Nile red was 560nm, and fluorescence peak wavelength was 590nm. From this, energy-level E2S1 of the minimum excitation singlet state was calculated with $17,400\text{cm}^{-1} (1 / 560 \times 10^{-7} + 1 / 590 \times 10^{-7}) (/2)$.

[0082] Moreover, when the 1st pulse laser (2nd higher harmonic of an YAG laser) and 2nd pulse laser were irradiated, the fluorescence by reverse intersystem crossing was observed.

[0083] About existence of the excitation triplet state of the 2nd henceforth, since fluorescence did not quench even when beta-ionone existed as a quencher, it turned out that it has an excitation triplet state in the energy level between $17,400\text{cm}^{-1}$ and $19,200\text{cm}^{-1}$.

[0084] When the electrical potential difference was impressed to the above-mentioned organic EL device and luminescence brightness was measured, the luminescence brightness when impressing an electrical potential difference 24V was 52 cd/m².

[0085] (Example 2 of a comparison) The organic EL device was obtained like the example 2 except having considered as the combination which shows the spreading solution in the case of component production in Table 2. In addition, in the example of a comparison, as shown in Table 2, fac-tris (2-phenyl pyridine) iridium was not used. When the electrical potential difference was impressed to the above-mentioned organic EL device and luminescence brightness was measured, the luminescence brightness when impressing an electrical potential difference 24V was 33 cd/m².

[0086]

[Table 2]

		配合量 (mg)	
		実施例 2	比較例 2
発光材料	fac-トリズ(2-フェニルピリジン)イリジウム	0.02	-
	ナイルレッド	0.10	0.10
ホール輸送材料	ポリ(N-ビニルカルbazol)	15.88	15.88
電子輸送材料	PBD	4.00	4.00
溶剤	クロロホルム	1980	1980
発光輝度 (cd/m ²)		52	33

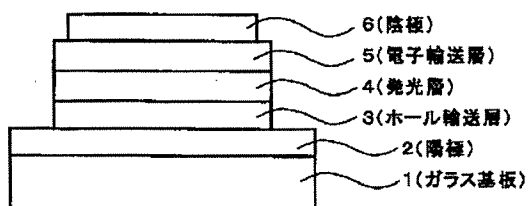
[0087] Energy-level E1T1 of the minimum excitation triplet state of the 1st organic compound is higher than energy-level E2S1 of the minimum excitation singlet state of the 2nd organic compound about two sorts of organic compounds contained in a luminous layer from the above result. And it became clear that luminescence brightness could be raised by at least one energy level of the excitation triplet state of said 2nd organic compound existing between E1T1 and E2S1, and filling the relation of emitting light from the 2nd organic compound.

[0088]
[Effect of the Invention] By using the luminescent material of this invention, it becomes possible to change the energy of an excitation triplet state into luminescence efficiently, and it becomes possible to offer the organic EL device which is durable by high brightness.

[0089]

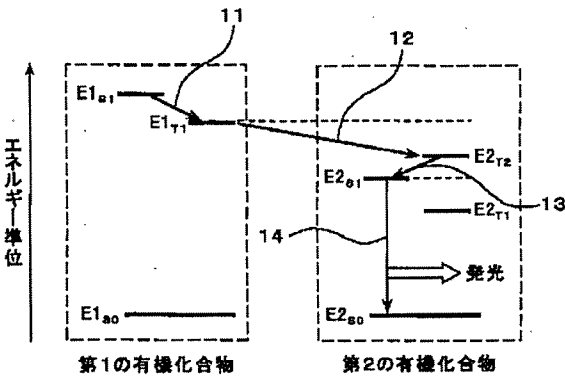
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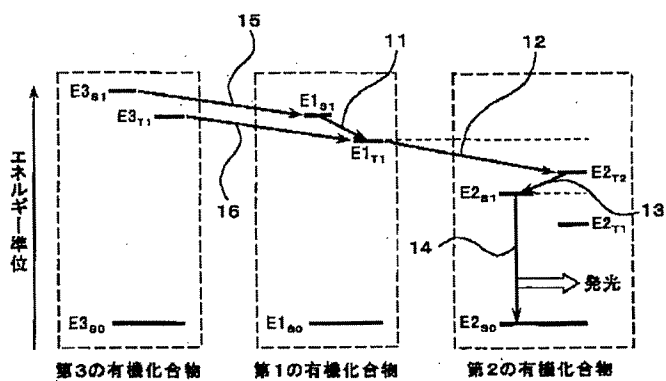


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